

**I. V. Gaivoronskiy, A. A. Kurtseva,
M. G. Gaivoronskaya, G. I. Nichiporuk**

**PERIPHERAL NERVOUS SYSTEM.
AUTONOMIC NERVOUS SYSTEM.
SENSE ORGANS**

**Периферическая нервная система.
Автономная нервная система.
Органы чувств**

The manual for medical students

*Учебное пособие для медицинских вузов
(специальность «Лечебное дело»)*

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Авторы:

Гайворонский Иван Васильевич — доктор медицинских наук, профессор, заведующий кафедрой нормальной анатомии Военно-медицинской академии им. С. М. Кирова и кафедрой морфологии медицинского факультета Санкт-Петербургского государственного университета;

Курцева Анна Андреевна — кандидат медицинских наук, доцент кафедры анатомии человека Курского государственного медицинского университета;

Гайворонская Мария Георгиевна — доктор медицинских наук, профессор кафедры морфологии НМИЦ им. В. А. Алмазова, доцент кафедры морфологии Санкт-Петербургского государственного университета;

Ничипорук Геннадий Иванович — кандидат медицинских наук, доцент кафедры нормальной анатомии Военно-медицинской академии им. С. М. Кирова и кафедры морфологии Санкт-Петербургского государственного университета

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Данное пособие является английской версией учебника профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 10 раз и одобрен Министерством здравоохранения Российской Федерации. Структура пособия соответствует современным стандартам медицинского образования в России и важнейшим европейским стандартам. Английская и латинская терминология приведены в соответствии с Международной анатомической номенклатурой.

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LIST OF ABBREVIATIONS

Art., art.	— articulatio
Artt., artt.	— articulationes
For., for.	— foramen
Lig., lig.	— ligamentum
Ligg., ligg.	— ligamenta
M., m.	— musculus
Mm., mm.	— musculi
N., n.	— nervus
Nn., nn.	— nervi
R., r.	— ramus
Rr., rr.	— rami
S., s.	— sulcus

PREFACE

The creation of the manual "Peripheral nervous system. Autonomic nervous system. Sense organs" in English meets the requirement of modern Russian medicine and education. Nowadays many English-speaking oversea students study in Medical Universities of Russia. Besides, many Russian school leavers have a good command of the English language so they will be able to use this manual taking into consideration the fact that many Russian specialists in medicine work abroad after graduating from the universities or take part in different international conferences and symposiums.

The English version of the manual is based on the Russian manual by professor I. V. Gayvoronskiy "Normal Human Anatomy" which has been published in Russia 10 times and is approved by the Ministry of education of Russia.

This manual introduces the main principles of Russian Anatomy School such as: detailed study of the general aspects and items of Anatomy including the development of organs and anomalies of the development. If we compare theoretical approaches to Anatomy in Russia and in other countries we'll see that our approach is based on the system descriptions of organs, i.e. we describe separately Skeletal system, Articulations, Muscular system etc. Moreover, we use Latin terminology while describing the organs and discuss clinicoanatomical and functional problems. As for the manuals in other countries many of them describe Anatomical systems in accordance with the regional and topographical principles.

The structure of our manual meets the requirements of modern standards of medical education in Russia which in their turn correspond to the major European standards. After each chapter we give test questions and clinicoanatomical problems. The English and Latin terminology is given in accordance with International Anatomical Nomenclature.

The authors strongly believe that the manual will allow future doctors to form the morphological foundation for the further study of theoretical and clinical disciplines. We also hope that it will be of great help to Anatomy teachers.

ПРЕДИСЛОВИЕ

Создание учебного пособия «Периферическая нервная система. Автономная нервная система. Органы чувств» на английском языке является требованием современной системы медицинского образования в России. В настоящее время в медицинских университетах нашей страны обучаются студенты из различных регионов дальнего зарубежья. Кроме того, многие выпускники российских школ хорошо владеют английским языком, поэтому они также смогут пользоваться данным пособием, принимая во внимание, что зачастую русские специалисты в медицине после окончания университета уезжают работать за рубеж или принимают участие в различных международных конференциях и симпозиумах.

Английская версия пособия базируется на русском учебнике профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 10 раз и одобрен Министерством образования Российской Федерации.

Данное пособие познакомит читателей с главными принципами Русской анатомической школы, которые заключаются в подробном изучении общих вопросов, в том числе развития органов и аномалий развития. В России преподавание анатомии ведется с функционально-клинических позиций и основано на описании органов по системам, т. е. отдельно изучается опорно-двигательная система, артросиндесмология, миология и другие системы. Также при описании строения органов акцентируется внимание на латинской терминологии. Что касается зарубежных руководств по анатомии человека, многие из них основываются на регионально-топографическом принципе без использования латинской терминологии.

Структура данного пособия соответствует современным стандартам медицинского образования в России, которые, в свою очередь, соответствуют важнейшим европейским стандартам. После каждой главы мы приводим контрольные вопросы и ситуационные клинические задачи. Английская и латинская терминология приведена в соответствии с Международной анатомической номенклатурой.

Авторы выражают уверенность, что данное пособие позволит будущим докторам сформировать морфологический фундамент для последующего изучения теоретических и клинических дисциплин. Мы также надеемся, что оно принесет определенную пользу и преподавателям анатомии человека.

1. GENERAL DATA OF PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system, *systema nervosum periphericum*, is a collection of the nerve structures situated outside the brain and spinal cord. This concept is based on anatomical and topographical characteristics of the nervous system which can be divided into central and peripheral parts.

In turn, the peripheral nervous system can be divided topographically into spinal and cranial parts; functionally into somatic (innervating the soma) and autonomic (vegetative) (innervating viscera, glands, vessels and smooth muscles).

The spinal somatic part comprises the anatomical structures associated with the spinal nerves:

- anterior and posterior spinal roots, *radix anterior et radix posterior*;
- spinal nerve trunk, *truncus n. spinalis*;
- spinal ganglion, *ganglion sensorium nervi spinalis*;
- spinal nerve branches (anterior, posterior, communicating, meningeal), *ramus anterior, ramus posterior, rami communicantes, ramus meningeus*;
- nerve plexuses (cervical, brachial, lumbar, sacral, coccygeal), *plexus cervicalis, brachialis, lumbalis, sacralis, coccygeus*;
- regional nerves and their branches;
- nerve endings (receptors and effectors).

The cranial part comprises the cranial nerves, sensory ganglia of the V, VII, VIII, IX and X cranial nerves, vegetative ganglia of the III, VII, IX and X cranial nerves, regional nerves and their branches, and nerve endings.

The vegetative part includes the anatomical structures which belong to the sympathetic and parasympathetic nervous system: vegetative ganglia and their branches, pre-ganglionic and postganglionic fibres, nerve endings of postganglionic fibres. Taking into consideration the features of the structure and function of the vegetative system, it will be described in another chapter.

It should be noted that despite significant morphological differences between somatic and vegetative parts of the nervous system, they are closely interconnected functionally.

Thus, the peripheral nervous system comprises the spinal and cranial nerves, the vegetative nerves and also the neurons situated outside the central nervous system and constituting the sensory or vegetative ganglia.

The nerves are formed by the neuron processes which unite into the nerve fibre bundles. The latter ones are covered by a connective tissue sheath, *perineurium*, consisting of collagen and elastic fibres. The perineurium extends between the separate nerve fibres, forming an internal connective tissue membrane, *endoneurium*. A nerve consisting of several bundles is surrounded by connective tissue sheath called *epineurium*.

The epineurium contains the blood and lymphatic vessels which supply the nerve, *vasa nervorum*, and nerves innervating the coats of the nerve, *nervi nervorum*. Usually, the nerves receive their blood supply from numerous sources that abundantly anastomose with each other. Thus, the epineurium includes the arterial network which is formed from the arteries supplying the neighboring organs; the arterial network is accompanied by analogous venous network. The perineurium receives only arterioles which also anastomose with each other and concomitant venules. The endoneurium contains only blood capillaries. The nerve coats are innervated by the branches arising from this nerve.

The nerve significantly differs in structure from each other. Each nerve has a certain number and diameter of the fibres and bundles, a certain thickness of the coats. The

structure of the same nerves varies in different people. For example, the number of the fibres in a median nerve cross-section, taken from different people and made at the same level, ranges from 19 000 to 32 000. The nerve fibres may pass from one bundle to another therefore, the diameter of the bundles constantly changes.

Based on their composition, the motor, sensory, mixed and vegetative nerves are distinguished.

The motor nerve, *n. motorius*, mainly consists of the nerve fibres formed by the axons from the neurons composing the nuclei proprii of the anterior spinal horns or the cranial nerve motor nuclei. Besides, it also contains few proprioceptive and sympathetic fibres.

The sensory neuron, *n. sensorius*, mainly consists of afferent nerve fibres which represent the peripheral processes of pseudounipolar or bipolar neurons whose somata are contained in the sensory spinal ganglia or cranial nerve ganglia. Most nerves are mixed in structure.

The mixed nerve, *n. mixtus*, may include the afferent, efferent and sympathetic fibres in different proportions and combinations; some cranial nerves also contain parasympathetic fibres.

The vegetative nerves, *nn. autonomici*, are formed by the preganglionic fibres, *neurofibrae preganglionicae*, or postganglionic fibres, *neurofibrae postganglionicae*. The preganglionic fibres originate from the neuronal somata composing the vegetative nuclei situated in the central nervous system. The postganglionic fibres pass from the neuronal somata located in the vegetative ganglia to the corresponding organs and tissues.

The motor nerves or motor fibres situated within the mixed nerves innervate the skeletal muscles, where they end with the motor plates (motor endings).

The sensory nerves or sensory fibres situated within the mixed nerve arise with polymorphic receptors in all the organs and end in the sensory ganglia. From here the sensory roots pass to the spinal cord and brain.

The vegetative nerves or vegetative fibres situated within the mixed nerves run to viscera, vessels, smooth musculature and glands.

The anterior branches of the spinal nerves, the nerves supplying the organs and situated close to each other may be connected by bridges, loops or arcades. Such connections are called the nerve plexuses, *plexus nervorum*. There are the somatic and vegetative nerve plexuses. The somatic plexuses are: cervical, brachial, lumbar, sacral and coccygeal. The vegetative plexuses are: coeliac, aortic, intramural etc.

According to the division of the peripheral nervous system into spinal, cranial and vegetative parts, it will be described in details in the following three chapters:

- spinal nerves, *nn. spinales*;
- cranial nerves, *nn. craniales*;
- vegetative nervous system, *systema nervorum autonomicum*.

2. SPINAL NERVES

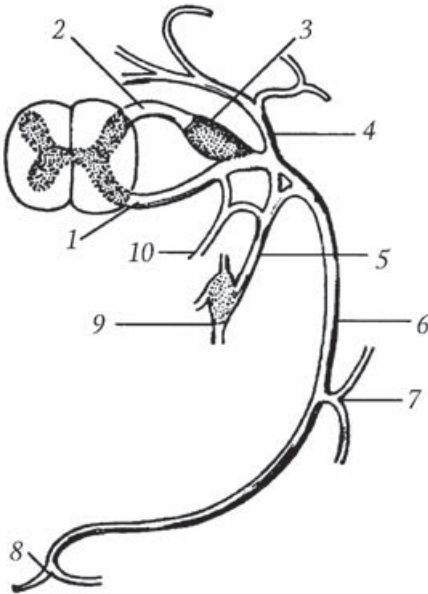


Fig. 2.1. The formation of a spinal nerve; the spinal nerve branches:

1 – anterior root; 2 – posterior root; 3 – spinal ganglion; 4 – meningeal branch; 5 – ramus communicans albus; 6 – anterior ramus; 7 – lateral cutaneous branch; 8 – nerve ending; 9 – ganglion of the sympathetic trunk; 10 – ramus communicans griseus

spinal ganglion located in the intervertebral foramen. The joining of the anterior root and peripheral processes of the pseudounipolar neurons located in the spinal ganglion form the trunk of the spinal nerve, *truncus n. spinalis*, about 1 cm long. The spinal nerves are mixed in fibre composition. All contain sensory and motor fibres; the spinal nerves from C8–L3 also include sympathetic fibres.

Leaving the intervertebral foramen, the spinal nerves divide into 3 or 4 branches. Each spinal nerve arising from C1–C7 and L4–Co1 gives 3 branches: meningeal, *r. meningeus*; posterior, *r. posterior*; anterior, *r. anterior*. Each spinal nerve arising from C8–L3 besides gives a white rami communicans, *r. communicans albus*, which is formed by preganglionic myelinated fibres ending in the sympathetic trunk's prevertebral ganglia. From these ganglia the grey rami communicantes, *rami communicantes grisei*, arise; they are formed by postganglionic non-myelinated fibres. Further, these fibres continue passing through the meningeal, posterior and anterior spinal nerve branches.

The meningeal branch contains sensory and sympathetic fibres. It innervates the spinal meninges and their vessels. The posterior and anterior branches are mixed; they innervate the skin, muscles and bones in the region of the trunk and limbs. These branches are composed of sensory, motor and sympathetic fibres. The sensory fibres start from the

According to the segmental structure of the spinal cord, humans have 31 pairs of the spinal nerves, *nn. spinales*. Like spinal segments, the spinal nerves can be arbitrary divided into 5 groups: 8 cervical, *nn. cervicales*; 12 thoracic, *nn. thoracici*; 5 lumbar, *nn. lumbales*; 5 sacral, *nn. sacrales*, and 1 coccygeal, *n. coccygeus*.

Each spinal nerve is associated anatomically and functionally with own spinal segment by two roots: anterior and posterior (fig. 2.1).

The posterior roots, *radices posteriores*, sensory, are represented by the central processes of the pseudounipolar neurons whose somata are located in the spinal ganglion, *ganglion sensorium nervi spinalis*.

The anterior roots, *radices anteriores*, motor, are formed by the axons arising from the motoneurons situated in the nuclei proprii of the anterior spinal horns. Besides, the anterior roots arising from C8–L3 contain sympathetic fibres which are formed by the axons arising from the neurons whose somata compose the intermediomedial nucleus located in the spinal cord's lateral horn.

The anterior and posterior spinal roots converge to each other at the level of the

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